NASA SBIR/STTR — Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2011 Phase I Solicitation

O4 Navigation

NASA seeks innovative research in the areas of positioning, navigation, and timing (PNT) that have relevance to Space Communications and Navigation programs and goals, as described at (https://www.spacecomm.nasa.gov/spacecomm/default.cfm). NASA's Space Communication and Navigation Office considers the three elements of PNT to represent distinct, constituent capabilities: - positioning, by which we mean accurate and precise determination of an asset's location and orientation referenced to a coordinate system - navigation, by which we mean determining an asset's current and/or desired absolute or relative position and velocity state, and applying corrections to course, orientation, and velocity to attain achieve the desired state - timing, by which we mean an asset's acquiring from a standard, maintaining within user-defined parameters, and transferring where required, an accurate and precise representation of time. This year, NASA seeks technology in Metric Tracking of Launch Vehicles, Position, Navigation, and Timing (PNT) Sensors and Components, and Flight Dynamics Technologies and Software. These areas include tracking during launch and landing operations, and research and technology relevant to the planning and development of PNT support and services that NASA may undertake over the next several years. Some of the subtopics in this topic could result in products that may be included in future flight opportunities. Please see the Science MD Topic S4 for more details as to the requirements for small satellite flight opportunities, and the Facilitated Access to the Space Environment for Technology Development and Training (FAST) website at (http://ipp.nasa.gov/ii_fast.htm).

Subtopics

O4.01 Metric Tracking of Launch Vehicles

Lead Center: KSC

Participating Center(s): GSFC, MSFC

The goal of this subtopic is to have a highly reliable way of tracking vehicles from launch to orbit. Launch vehicles can exhibit high dynamics during flight and there can be external interference on the GPS frequency. Proposals can either address a single area as described below or a combination of multiple areas. The following technology areas are of interest:

Position, Attitude, and Inertial Metrics

Metric tracking of launch vehicles requires the development of accurate and stable integrated metric tracking and inertial measurement units. The focus is on technologies that enable and advance development of low Size, Weight, and Power (SWaP), tactical grade, integrated metric tracking units that provide accurate and stable positioning, attitude, and inertial measurements on high dynamic platforms. Factors to address include:

- Ultra-tight coupling of rate sensors, accelerometers, and attitude determining GPS receivers that will provide very high frequency integrated metric solutions.
- The ability to reliably function on spin-stabilized rockets (up to 7 rev/s), during sudden jerk and acceleration maneuvers, and in high vibration environments.
- Advancements in MEMs-based rate sensors and accelerometers, algorithm techniques and Kalman filtering, high bandwidth and low noise outputs, phased-based attitude determination, single aperture systems, quick Time to First Fix and reacquisition.
- Robust tracking during separation.

Use of GPS and Ability to Mitigate Interference Signals

Innovative technologies to increase the accuracy of the L1 C/A navigation solution by combining the pseudo ranges and phases of the L1 C/A signals, and use of the L2 and L5 carriers. Factors that degrade the GPS signals can be obtained by differencing the available carrier phase and pseudo range measurements and then removing these differences from the navigation solution.

Technologies are sought that combine spatial processing of signals from multiple antennas with temporal processing techniques to mitigate interference signals (jamming) received by the GPS receiver. The coordinated response of adaptive pattern control (beam and null steering) and digital excision of certain interfering signal components can minimize strong jamming signals. Adaptive nulling minimizes interfering signals by the optimal control of the GPS antenna pattern (null steering).

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I (to reach TRL 3) and show a path toward Phase II hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase II contract (to reach TRL 5).

Phase I Deliverables:

- Midterm Technical Report.
- Final Phase I Technical Feasibility Report with a Phase II Integration Path. Proof-of-concept bench top demonstration preferred.
- Verification matrix of measurements to be performed at the end of Phase II, along with specific quantitative pass-fail ranges for each quantity listed.

Phase II Deliverables:

- Working model of proposed product, along with full report of development and measurements, including populated verification matrix from phase II (TRL 5).
- Final Phase II Technical Report.
- Demonstration hardware/software/field test.
- Opportunities and plans should also be identified and summarized for potential commercialization.

O4.02 PNT (Positioning, Navigation, and Timing) Sensors and Components

Lead Center: GSFC

Participating Center(s): ARC, GRC, JPL, JSC

This subtopic seeks proposals that will serve NASA's ever-evolving set of near-Earth and interplanetary missions that require precise determination of spacecraft position and velocity in order to achieve mission success. While the definition of "preciseÂ“ depends upon the mission context, typical scenarios have required meter-level or better position accuracies, and sub-millimeter-level per sec or better velocity accuracies. This solicitation is primarily focused on NASA's needs in four focused areas identified below.

Proposals are encouraged that leverage the following NASA developed state of-the-art capabilities:

- GEONS:
  - NASA Copyright, licensable technology.
  - (http://ipp.gsfc.nasa.gov/ft_tech_geons.shtm).
  - AutoNav (NTR 43546 Deep Impact Autonomous Navigation (AutoNav) Flight Software 23-FEB-2006).
- Navigator:
  - US Patent 7,548,199.
  - http://patft1.uspto.gov/netacgi/nph-Parser?patentnumber=7548199.
  - http://techtransfer.gsfc.nasa.gov/ft_tech_gps_navigator.shtm.

- GIPSY:
    - https://gipsy-oasis.jpl.nasa.gov/.
- Electra:
    - http://descanso.jpl.nasa.gov/Monograph/series9_chapter.cfm.
- Blackjack:
    - http://www.jpl.nasa.gov/releases/2000/blackjackgps.html.

NASA is not interested in funding efforts that seek to "re-invent the wheel" by duplicating the many investments that NASA and others have already made in establishing the current state-of-the-art. We seek to maximize the work listed above in the new work sought for this subtopic.

General Operational Needs, Requirements and Performance Metrics:

Onboard Near-Earth Navigation Systems

NASA seeks proposals that would develop a commercially viable transceiver with embedded orbit determination software to provide enhanced accuracy and integrity for autonomous onboard GPS- and TDRSS-based navigation and time-transfer in near-Earth space via augmentation messages broadcast by the proposed TDRSS Augmentation for Satellites Signal (TASS; http://www.gdgps.net/system-desc/papers/Bar-Sever.pdf). Innovations that will increase the integration, reducing the size, weight, and power of such transceiver platforms, and improving their performance in high radiation environments, are sought. Proposers are advised that NASA's GEONS and GIPSY orbit determination software packages already support the capability to ingest TASS messages.

Onboard Deep-Space Navigation Systems

NASA seeks proposals to develop an onboard autonomous navigation and time-transfer system for reduction of DSN tracking requirements. Such a system should provide accuracy comparable to delta differenced one-way ranging (DDOR) solutions anywhere in the inner solar system, and exceed DDOR solution accuracy beyond the orbit of Jupiter. Proposers are advised that NASA's GEONS and AutoNav navigation software packages already support the capability to ingest many one way forward Doppler, optical sensor observation, and accelerometer data types. In addition, NASA is seeking innovative solutions in the area of planetary surface navigation.

Technologies Supporting Improved TDRSS-Based Navigation

NASA seeks proposals providing improvements in TDRS orbit knowledge, TDRSS radiometric tracking, ground-based orbit determination, and Ground Terminal improvements that improve navigation accuracy for TDRS users. Methods for improving TDRS orbit knowledge should exploit the possible future availability of accelerometer data collected onboard future TDRS. The goal is navigation and communications integrated into a single processor.

).

Navigation Payload Technology for Planetary Relay Satellites

NASA seeks planetary relay navigation payload technologies that can:

- Transmit accurate spread spectrum signals (emphasizing the stability of the frequency reference yielding accurate timing and chipping rate of the PN code and a low noise carrier).
- Receive same in return (either in coherent mode (the relay transmits and receives using the same frequency reference) or non-coherent mode (where the accurate frequency reference is on one end of link, either the transmit side or the receive side)).

This relay navigation payload should be capable of receiving a satellite-to-satellite link with similar signal properties. The relay navigation payload has to measure the range (two-way), pseudo-range (one-way), and both one-way and two-way Doppler. The relay navigation payload must be able to de-commutate data received from Earth and bases on other planetary surfaces to maintain time synchronization with a master time source, use the data onboard to either slave its frequency reference or to update its reference, and turn-around the data to modulate onto the user data stream.

Additionally, the relay navigation payload must have:

- 'Reasonable fidelity' autonomous filtered navigation capability to fuse all data types listed above as well as antenna gimbal angles, accelerometer data, and rendezvous radar data, to estimate the lunar relay state.
- Output data rates of 1 Hz for the states of multiple satellites and comprehensive fault detection and correction data.
- State outputs that can be modulated on transmitted data streams.
- TASS-like broadcast beacon capability for navigation. The data on the beacon can originate either at a base location (earth, moon), the relay, or another asset with which the relay communicates.
- Dissemination of time and navigation data for the local environment.

Proposals can either address a single subject as described above or a combination of subjects.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I (to reach TRL 3) and show a path toward Phase II hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase II contract (to reach TRL 5).

Phase I Deliverables:

- Midterm Technical Report.
- Final Phase I Technical Feasibility Report with a Phase II Integration Path. Proof-of-concept bench top demonstration preferred.

Phase II Deliverables:

- Final Phase II Technical Report.
- Demonstration hardware/software/field test.

O4.03 Flight Dynamics Technologies and Software

Lead Center: GRC

Participating Center(s): ARC, GSFC, JPL

NASA is beginning to invest in re-engineering its suite of tools and facilities that provide navigation and mission design services for design and operations of mid-term and long-term near-Earth and interplanetary missions. This solicitation seeks proposals that will develop the highly desired flight dynamics technologies and software that support these efforts.

Proposals that leverage state-of-the-art capabilities already developed by NASA are especially encouraged, such as:

- GPS-Enhanced Onboard Navigation Software: http://techtransfer.gsfc.nasa.gov/ft_tech_gps_navigator.shtm.
- General Mission Analysis Tool: http://sourceforge.net/projects/gmat/.
- GPS-Inferred Positioning System and Orbit Analysis Simulation Software: http://gipsy.jpl.nasa.gov/orms/goa/.
- Optimal Trajectories by Implicit Simulation: http://otis.grc.nasa.gov/.

Proposers who contemplate licensing NASA technologies are highly encouraged to coordinate with the appropriate NASA technology transfer offices prior to submission of their proposals.

Areas of interest: In the context of this solicitation, flight dynamics technologies and software are algorithms and software that may be used in ground support facilities, or onboard a spacecraft, so as to provide Position, Navigation, and Timing (PNT) services that re-duce the need for ground tracking and ground navigation support. Flight dynamics technologies and software also provide critical support to pre-flight mission design, planning, and analysis activities.

This solicitation is primarily focused on NASA's operational needs in the following focused areas:

- Applications of cutting-edge estimation techniques, such as, but not limited to, sigma-point and particle filters, to spaceflight navigation problems.
- Applications of estimation techniques that have an expanded state vector (be-yond position and velocity components) to monitor non-Gaussian state noise processes and/or non-Gaussian measurement noise processes.
- Applications of estimation techniques that combine measurements from multiple sensor suites in a highly coupled manner to improve upon the overall system ac-curacy.
- Addition of novel estimation techniques to existing NASA mission design software that is either freely available via NASA Open Source Agreements, or that is licensed by the proposer.
- Applications of advanced dynamical theories to space mission design and analysis, especially in the context of unstable orbital trajectories in the vicinity of small bodies and libration points.
- Addition of novel measurement technologies to existing NASA onboard navigation software that is licensed by the proposer.
- Addition of orbit determination capabilities to existing NASA mission design software that is either freely available via NASA Open Source Agreements, or that is licensed by the proposer.

Technologies and software should support a broad range of spaceflight customers. Technologies and software specifically focused on a particular mission's or mission set's needs, for example rendezvous and docking, or formation flying, are the subject of other solicitations by the relevant sponsoring organizations and should not be submitted in response to this solicitation.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I (to reach TRL 3) and show a path toward Phase II hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase II contract (to reach TRL 5).

Phase I Deliverables:

- Midterm Technical Report.
- Final Phase I Technical Feasibility Report with a Phase II Integration Path.

Phase II Deliverables:

- Final Phase II Technical Report.
- Algorithm Specification.
- Delivery of software package.
- Demonstration of software package.